Zero Energy Homes Performance

Presentation to RESNET
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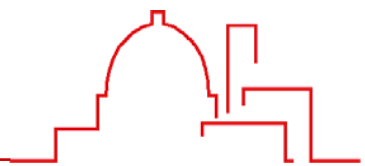
San Antonio, Texas

Mike Keesee
PV Project Manager
Renewable Generation Assets
SMUD



Agenda

- SMUD's New ZEH Experience
- Benefits of ZEH
- Lessons Learned

Why Solar?

- Fulfills Utility's RPS commitment
- State Efficiency Standards are reaching their limits
- Reduces summer peak, yet preserves off-peak sales
- Creates local jobs
- Delays need for new plants and transmission upgrades
- Customer choice

Why PV In Residential New Construction?

- Residential New Construction is PV's "Holy Grail"
  - High volume drives down costs
  - Standardized system design
  - Builders masters of cost cutting
  - Lowest cost install
  - Highest growth opportunity for PV
- Zero Energy Homes
  - Energy efficiency with 2 kW PV Energy Roofs
  - Potential: 20+MW DG capacity in District per year
  - 260+ MW DG capacity statewide per year

SMUD'S New Home PV Experience

- Initiated December 2000
- Eight production home Builders
- 196 new homes & townhouses in 19 subdivisions
- First production home ZEH – Beazer Powerhouse
- 100+ ZEH homes built

Residential New Construction PV Projects

SMUD'S ZEH Experience

- Beazer Homes (18 homes)
- Morrison Homes (20 homes)
- Premier Gardens (95 homes)

Beazer Powerhouse

- Entry Level buyers
- 1300 to 2400 square foot homes
- Very diverse community demographics
- ZEH offered as optional upgrade in 4 communities
- 18 Homes built (approx. 60 kW)
  - 17 occupied by owner for 1+ year

POWERHOUSE EFFICIENCY FEATURES

Up to 75% > 99 Title-24 Cooling Energy Stds

Envelope	Base	ZEH
Roof	R-30	**R-38**
Windows	metal	**Vinyl, Low SH**
HVAC		
A/C SEER	10	**14 w/TXV**
Duct Insulation	R-4.2	**R-20**
Duct Sealing	Standard	**Sealed**
ACCA Design	No	**Yes -- Short Runs**

POWERHOUSE PV SYSTEM

- Atlantis Sunslates (216-360 slates/home)
  - 3.3 kW AC
- Multiple Source Circuits
- Low-Voltage
- Xantrex Inverters
- PV System Sizing
  - 4,000 kWh/year

SMUD's Participation

- Residential Services programs
  - Hook-up fee refund for high efficiency homes
- Buydown of the PV system
  - Costs ≈ $10.45 /watt AC Installed
  - Builder pays $4/watt ($2.60/w equipment + install $1.40/w)
  - $6.45/w AC PV Buydown
- Installation Support
- Marketing Support
- Net Metering

DOE's Zero Energy Home Program Goals

- Communities Built in 2003 – 2004
  - 60% reduction in energy bill
  - Annual net-zero electricity use
  - $600 total annual energy bill
- Communities built by 2010
  - Annual net-zero energy use

COMPLIMENTARY PROGRAMS

- Energy Star

  Energy Star (15% better than Title 24)

- ComfortWise

  Third Party inspections and tests

- SMUD Tier III Advantage Home

  50% reduction in Title 24 cooling energy budget

Morrison Lakeside ZEH Project

- 120 unit in-fill, move-up, second time buyer+ community
- 2200 to 3600 square foot homes
- Affluent Buyer
- ZEH Optional Feature
- 12 Homes built (24 kW Solar)
- Occupied < one year

SMUD Sacramento Municipal Utility District

energy Money Isn't All You're Saving

ComfortWise

ASTROPOWER

Morrison Homes

Premier Gardens ZEH Project

- 95 unit in-fill, entry level community
- 1300 to 2400 square foot homes
- Very diverse community demographics
- ZEH Standard Feature
- 95 Homes built (190 kW Solar)
- Occupied < one year

SMUD Sacramento Municipal Utility District

Energy Money Isn't All You're Saving

ComfortWise

GE Energy

231 Lake Drive, Newark, DE 19702

Premier Homes

Building Integrated Solar Electric System

- PIER Support PV Product Development
- 48 GE Energy GT 55 BIPV Modules
  - 2,208 kW AC CEC
- One Source Circuit
- High-Voltage
- SMA 2500 Inverter
- PV System Sizing
  - Building America Features
  - ConSol Engineering Analysis

SMUD's Participation – Energy Efficiency

- $500 Hook-up fee discount
- $200 Lighting and Energy Star Home (3rd party inspection) incentives
- $20,000 Marketing Support

SMUD's Participation - Solar

- Buydown of the PV system - Morrison
  - Installed costs ≈ $8.75/w AC
  - Builder pays $4/watt ($2.60/w equipment + install $1.40/w)
  - $4.75/w AC PV buydown (12 homes w/ 2 kW PV system)
- Buydown of the PV System – Premier
  - Costs ≈ $7.76 /watt AC Installed
  - Builder pays $4.26 (PV equipment + install)
  - $3.50/watt AC Average PV Buydown

ZEH Features Lakeside

37% to 43% > 01 Title-24 Standards

Measure	Base	ZEH
Attic Insulation	R-30	**R-38**
Low Air Infiltration	No	**Yes**
Wall Insulation	R-13	**R-13 + R-4.2 Foam**
Windows	Vinyl, Low-e	**Vinyl, Low SHGC**
FURN AFUE	0.78	**0.92**
A/C SEER	10	**14 w/TXV**
ACCA Design	Yes	**Yes -- Short Runs**
Ducts	R-4.2	R-20
Water Heater	storage EF .60	**Tankless EF .87**
Distribution	Standard	**Pipe insulation**
	NA	**Fluorescent Lighting**
	NA	**2kW AC PV**
	NA	**Third Party Inspections & Tests**

Premier ZEH Features vs.. Neighbor

32% to 38% > 01 Title-24 Standards

Measure	Neighbor	ZEH
Attic Insulation	R-30	**R-38**
Wall Insulation	R-13	**R-13 + R-4.2 Foam**
Low Air Infiltration	No	**Yes**
Windows	Vinyl, low SHGC	**Vinyl, Low SHGC**
FURN AFUE	0.80	**0.92**
A/C SEER	10	**14 w/TXV**
ACCA Design	YES	**YES -- Short Runs**
Duct Leakage	TIGHT	**TIGHT**
Water Heater	storage EF .62	**Tankless EF .87**
Distribution	Standard	**Pipe insulation**
	NA	**Fluorescent Lighting**
	NA	**2kW AC PV**
	NA	**Third Party Inspections & Tests**

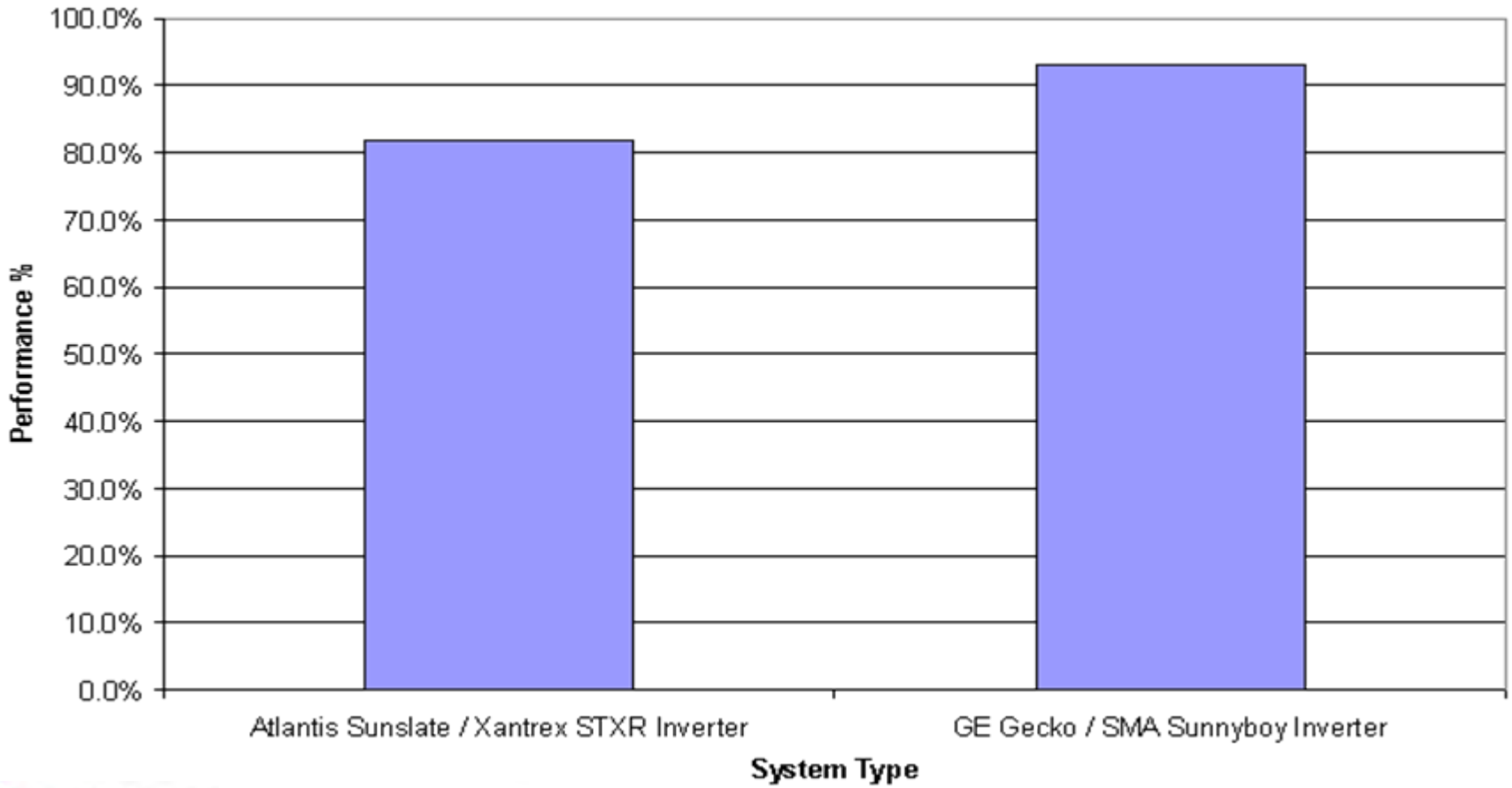
ZEH Potential Impacts

- PV System Performance
- Demonstrated total annual energy bill reduction without losing Off-Peak electricity sales
- Potential Peak Demand Savings – up to 20+ MW/year

SMUD PV Fleet Performance

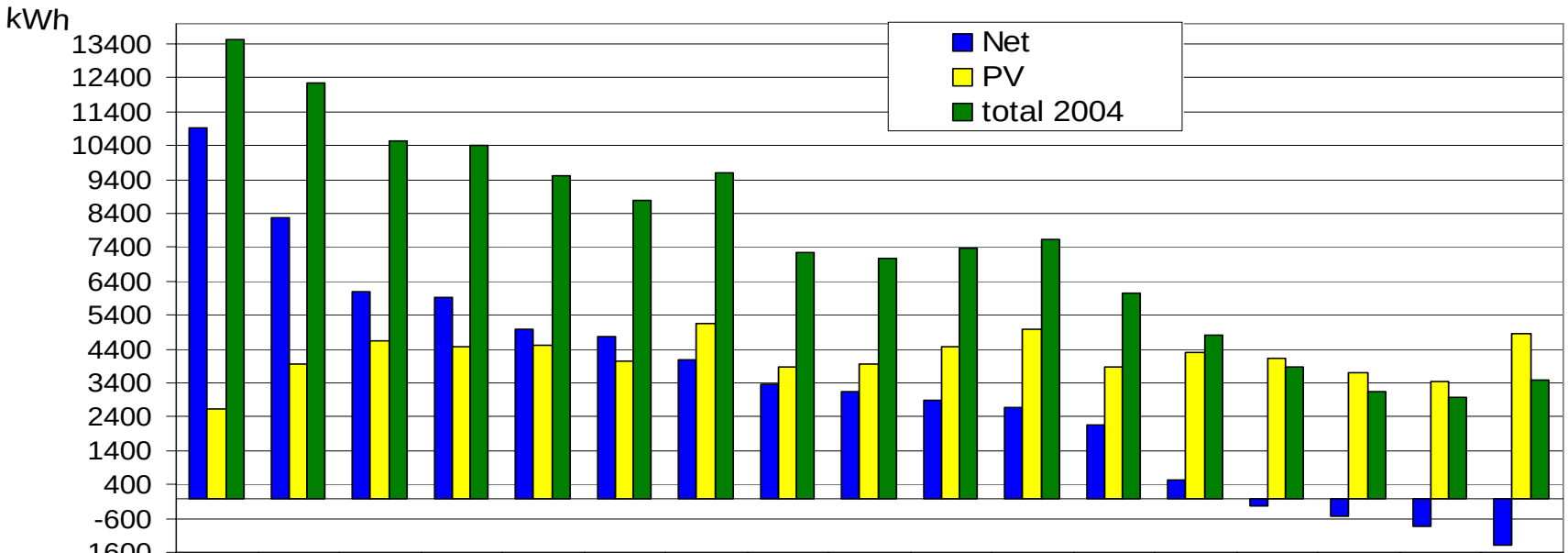
	PV 2 Residential Retrofit	Utility Scale	C&I Old	C&I New	New Homes
kWh/kW	1394	940	1061	1411	1413
Capacity Factor	15.9%	10.6%	12.1%	16.1%	16.2%

Performance of Residential New Construction PV Systems



Beazer Powerhouse Annual kWh Consumption

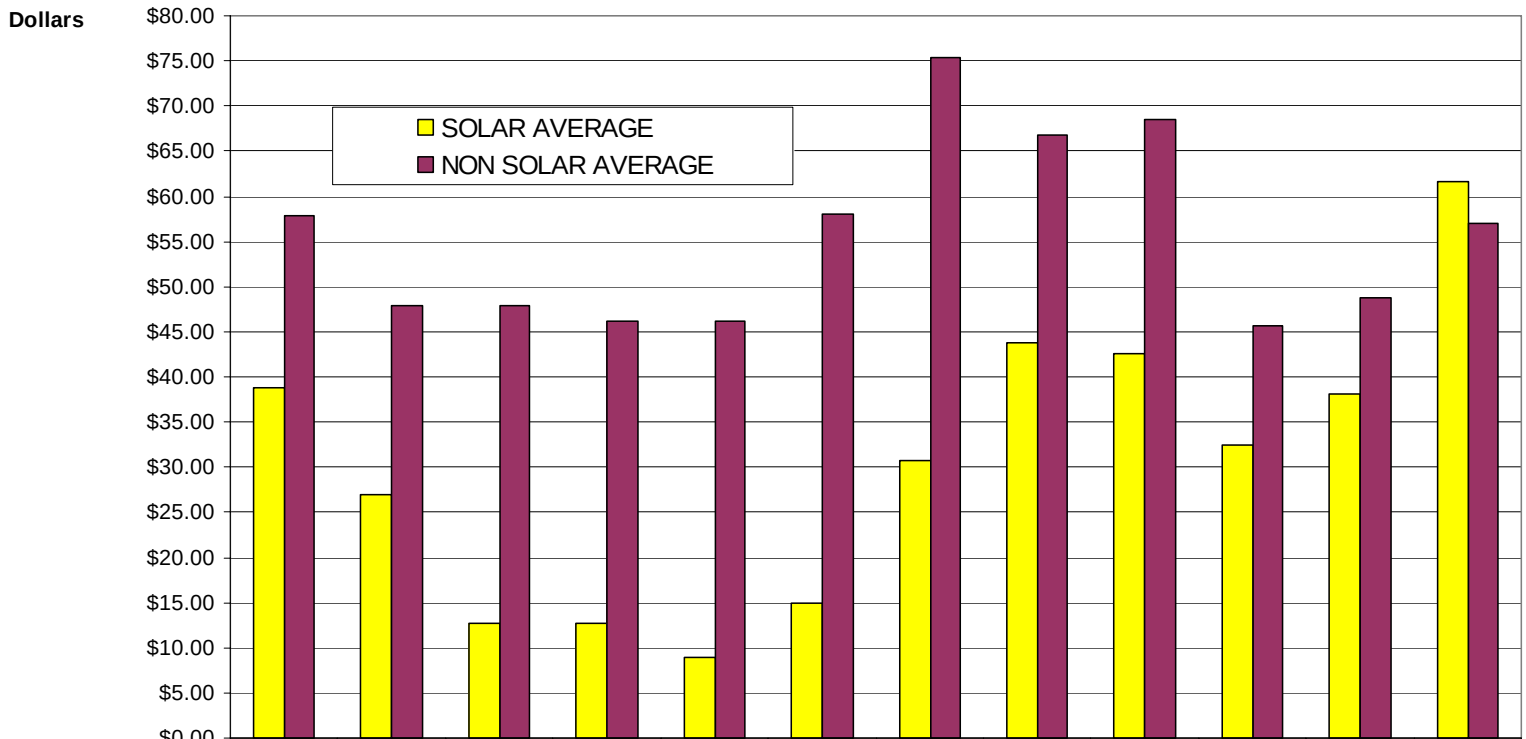
Solar Averaged 68% of Annual kWh Consumption
11 of 17 owner occupied homes produced more electricity than they purchased from SMUD



	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Net	10913	8278	6102	5911	5000	4758	4093	3360	3143	2892	2655	2173	535	-229	-551	-845	-1373
PV	2611	3953	4633	4480	4501	4041	5148	3890	3950	4481	4983	3891	4292	4121	3682	3448	4875
total 2004	13524	12231	10522	10391	9501	8799	9608	7250	7093	7373	7638	6064	4827	3892	3131	2967	3502

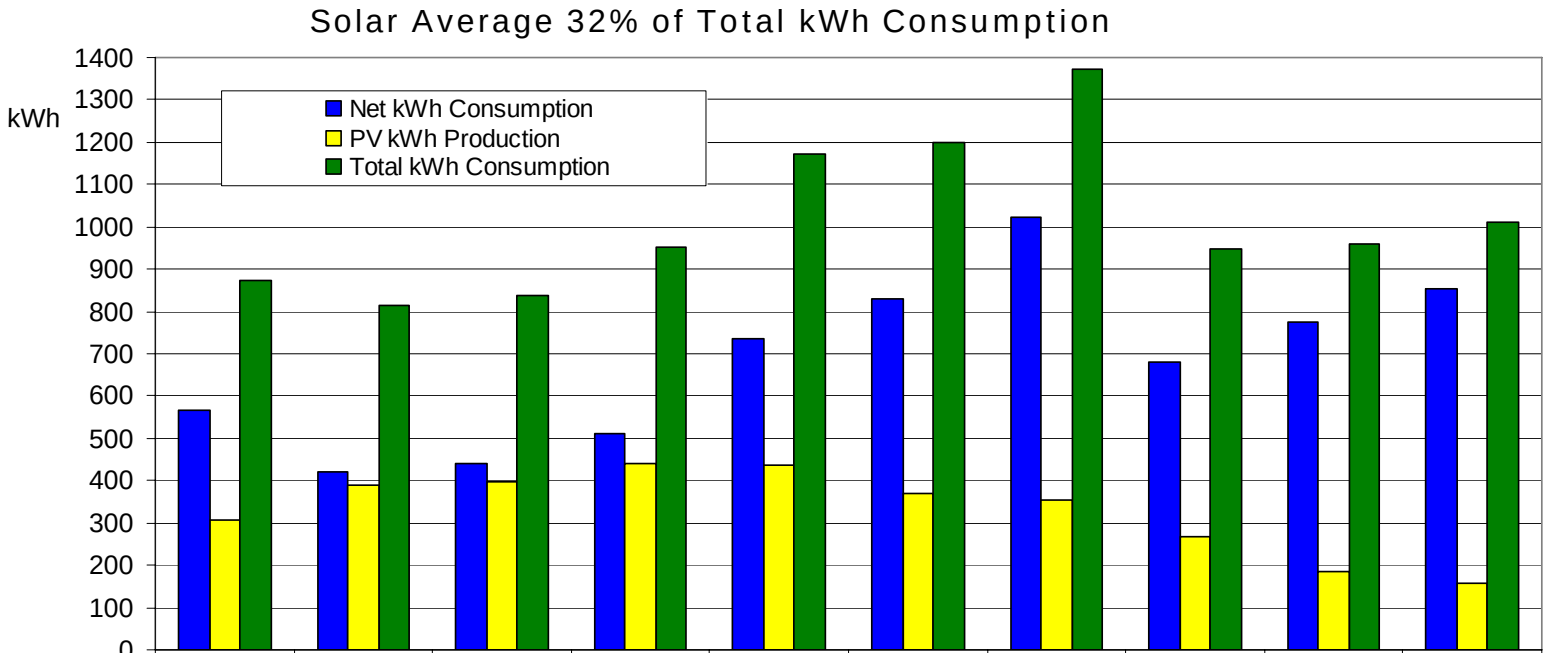
Beazer (Piazza) Solar vs.. Non Solar Average Electric Bills

ZEH Homeowner Electric Bills were 45% lower than Non-ZEH Homeowner Electric Bills



	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec
SOLAR AVERAGE	$38.85	$27.01	$12.66	$12.64	$8.94	$14.91	$30.68	$43.84	$42.52	$32.48	$38.10	$61.71
NON SOLAR AVERAGE	$57.86	$47.96	$47.94	$46.11	$46.25	$58.00	$75.40	$66.82	$68.44	$45.71	$48.80	$57.05

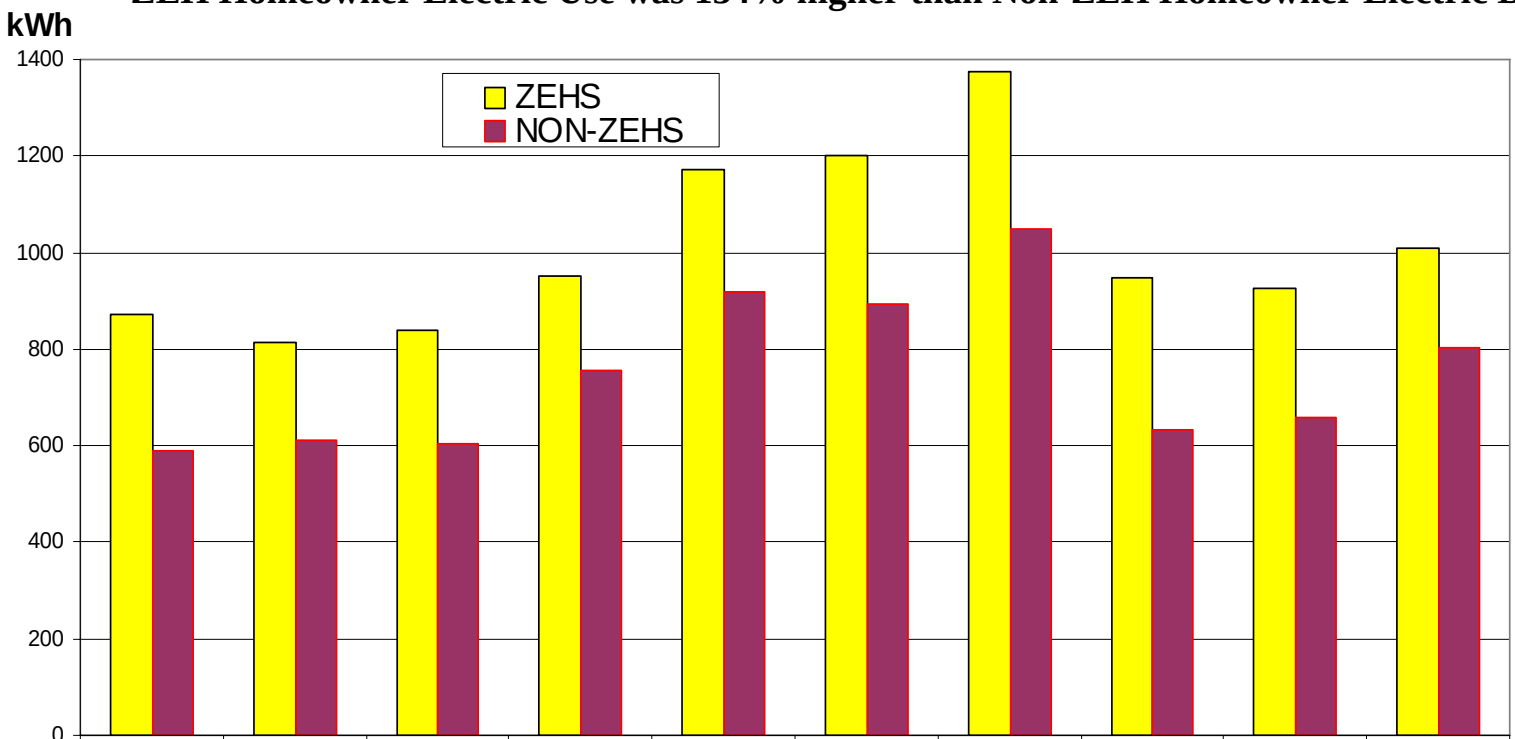
Lakeside ZEH 2004 Monthly Avg PV & Net kWh Usage



	March	April	May	June	July	Aug	Sept	oct	nov	dec
Net kWh Consumption	565	422	441	510	736	831	1021	681	775	852
PV kWh Production	307	391	398	440	436	369	353	266	186	159
Total kWh Consumption	872	813	839	950	1172	1200	1374	947	961	1011

Lakeside 2004 Monthly Avg kWh Usage ZEH vs.. Non-ZEh

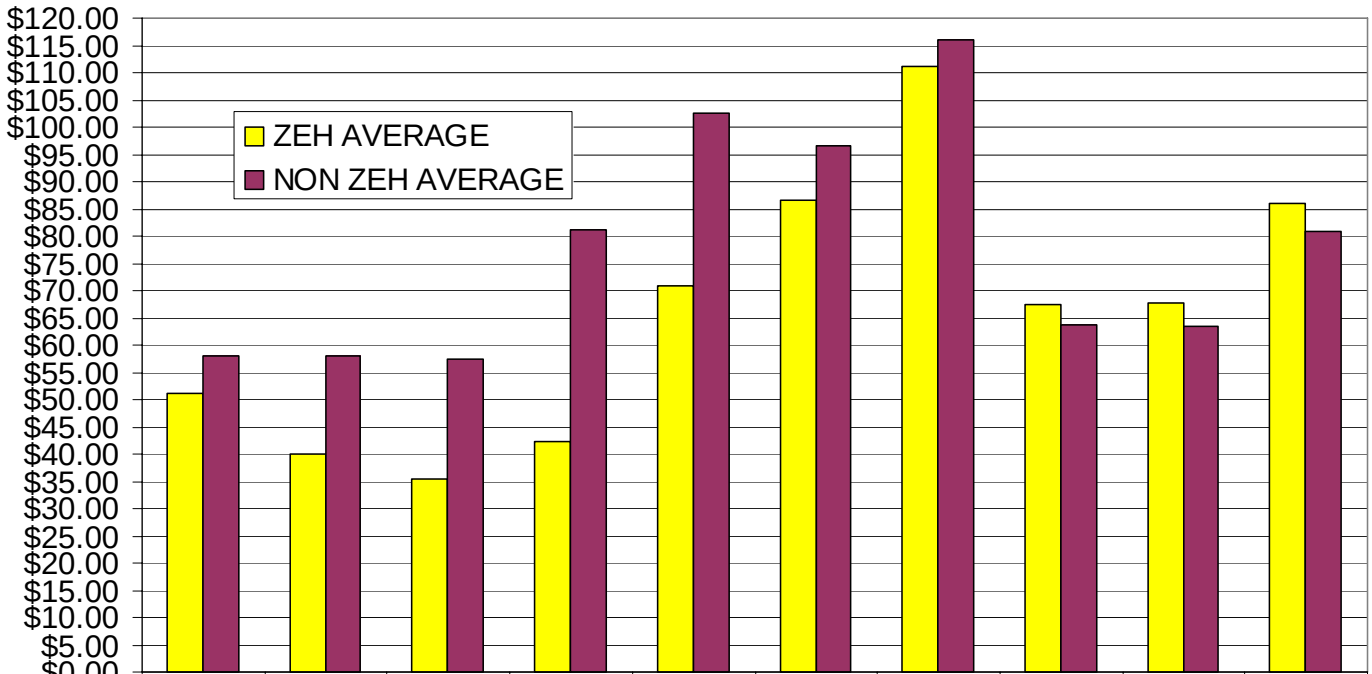
ZEH Homeowner Electric Use was 134% higher than Non-ZEH Homeowner Electric Bills



	Mar-04	Apr-04	May-04	Jun-04	Jul-04	Aug-04	Sep-04	Oct-04	Nov-04	Dec-04
ZEHS	872	813	839	950	1172	1200	1374	946	927	1011
NON-ZEHS	588	613	603	754	920	895	1047	633	659	802

Morrison Avg 2004 Monthly Electric Bills ZEH vs.. Non ZEh

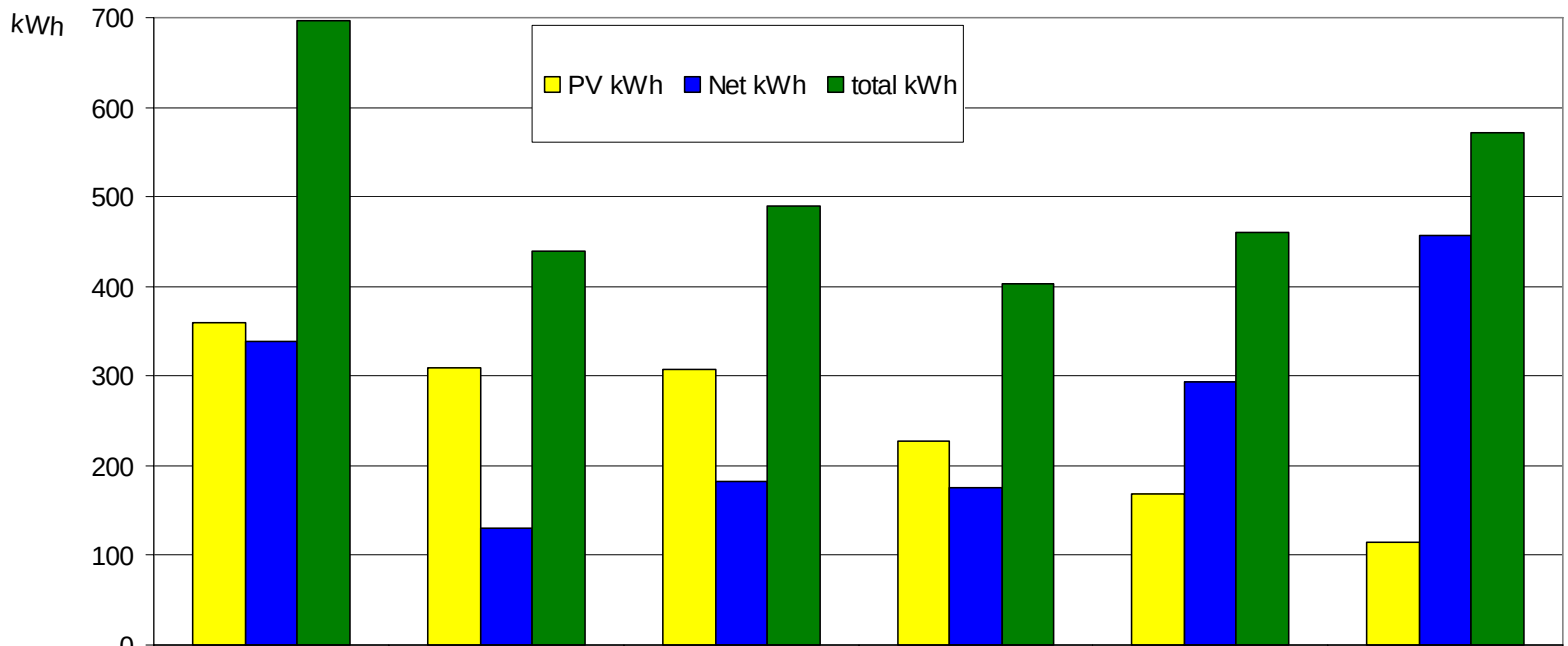
ZEH Homeowner Electric Bills were 4% lower than Non-ZEH Homeowner Electric Bills



	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec
ZEH AVERAGE	$51.20	$39.99	$35.33	$42.27	$70.98	$86.65	$111.26	$67.39	$67.63	$86.08
NON ZEH AVERAGE	$58.03	$58.13	$57.47	$81.03	$102.60	$96.47	$115.87	$63.84	$63.35	$80.74

Premier ZEH 2004 Monthly Avg PV & Net kWh Usage

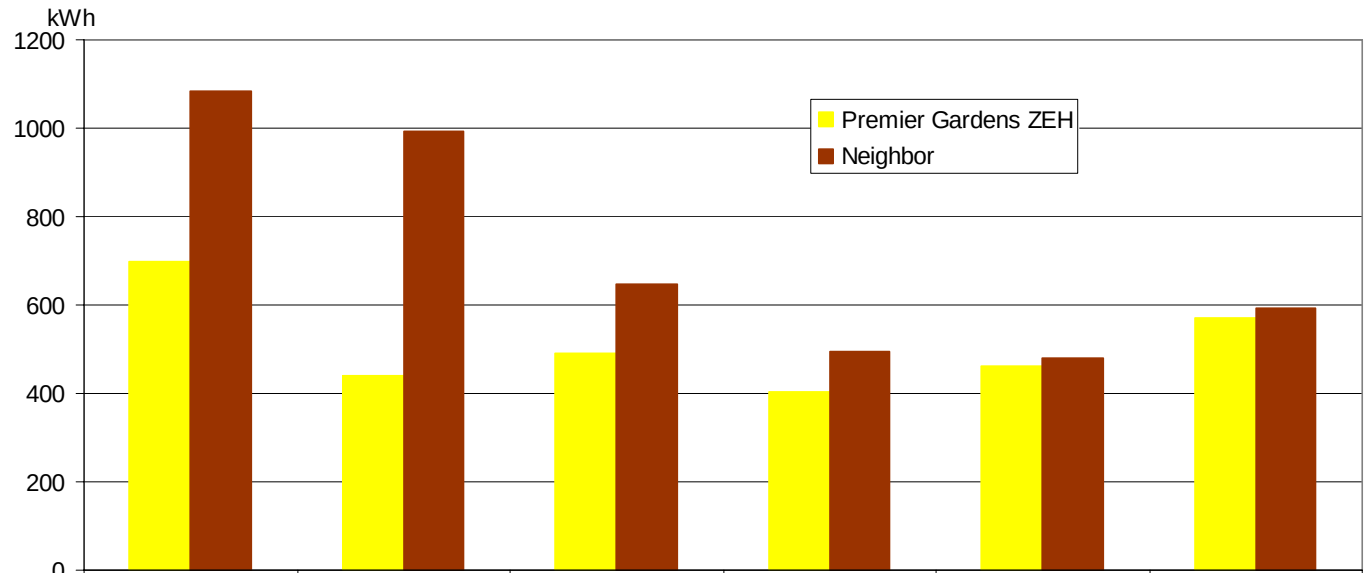
Solar Averaged 49% of Total kWh Consumption



	juy	aug	sept	oct	nov	dec
PV kWh	359	310	307	228	168	115
Net kWh	338	130	182	175	293	456
total kWh	697	440	489	403	461	571

Monthly Average Monthly kWh Usage Premier vs.. Neighbor

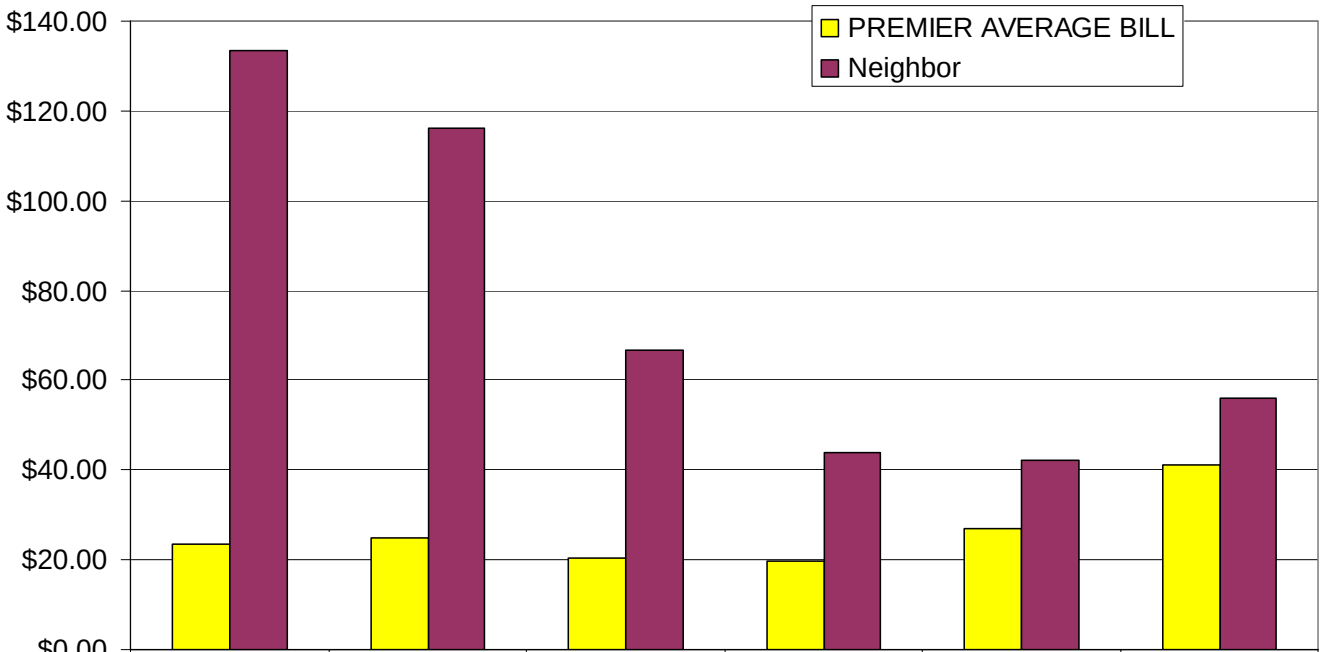
Premier ZEH Averaged 29% less kWh Consumption than Neighbor



	July	Aug	Sept	Oct	Nov	Dec
Premier Gardens ZEH	697	440	489	403	461	571
Neighbor	1082	992	649	495	480	594

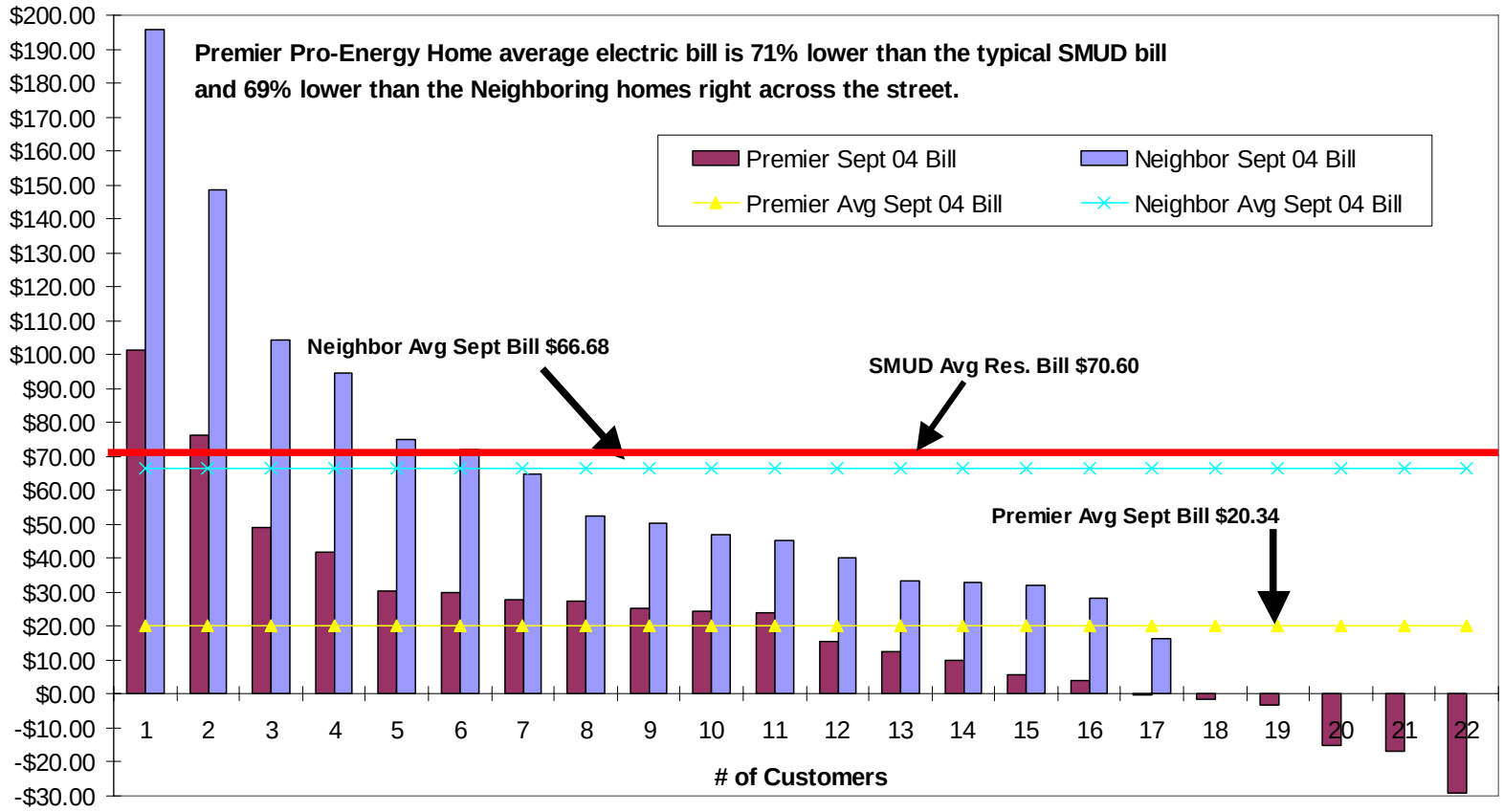
Premier vs.. Neighbor 2004 Average Monthly Electric Bills

ZEH Homeowner Electric Bills were 44% lower than Non-ZEH Homeowner Electric Bills



	July	Aug	Sept	Oct	Nov	Dec
PREMIER AVERAGE BILL	$23.58	$24.91	$20.34	$19.55	$26.92	$41.02
Neighbor	$133.29	$116.26	$66.68	$43.83	$42.13	$55.87

Premier vs.. Neighbor Sept 04 Electric Bills



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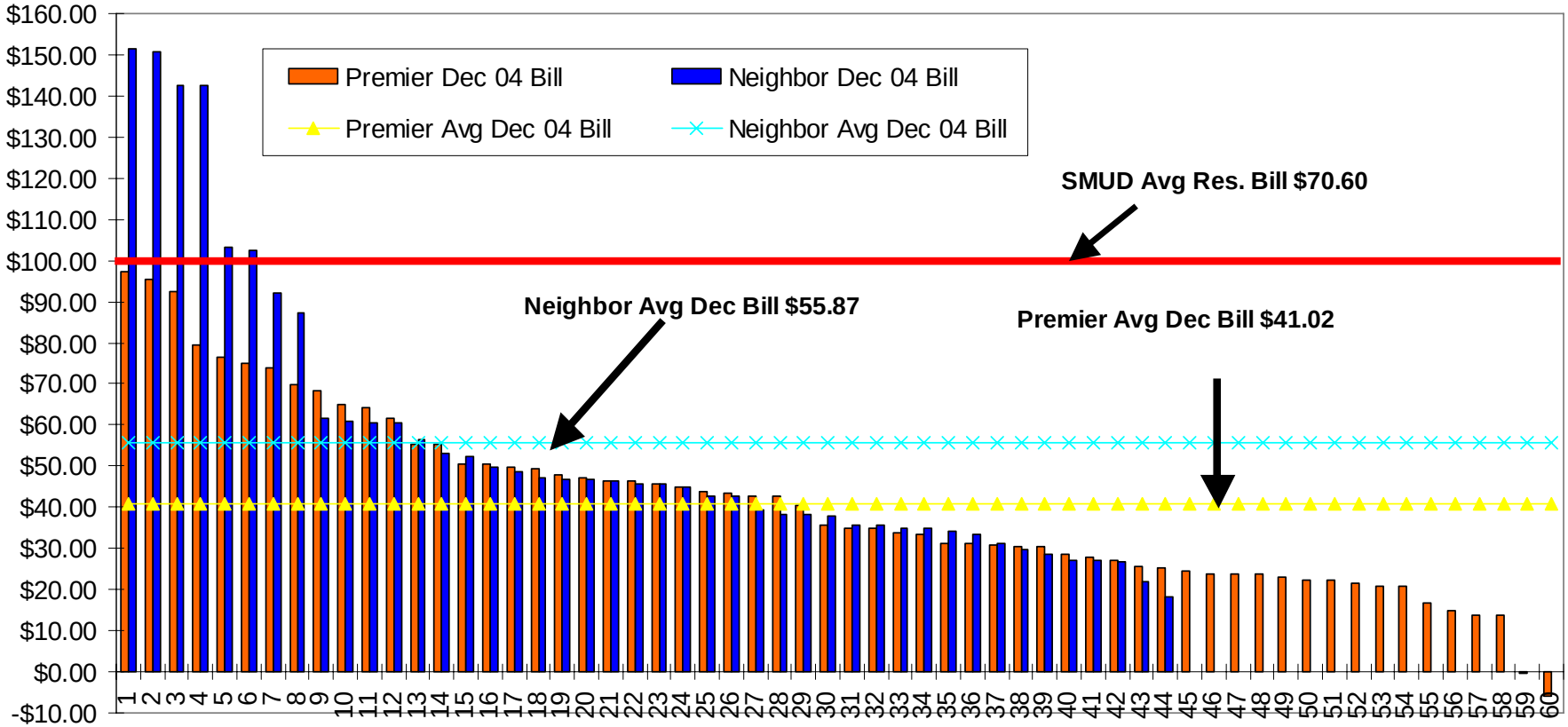
Premier vs.. Neighbor Dec 04 Electric Bills

Premier Pro-Energy Home average electric bill is 42% lower than the typical SMUD bill and 27% lower thar the Neighboring homes right across the street.



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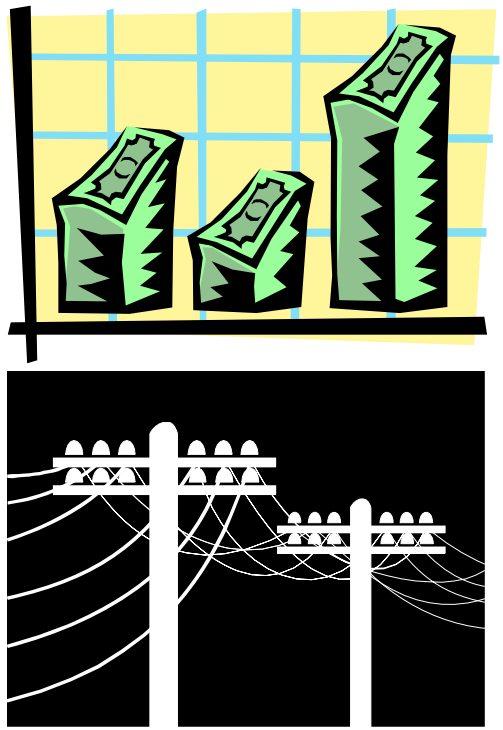
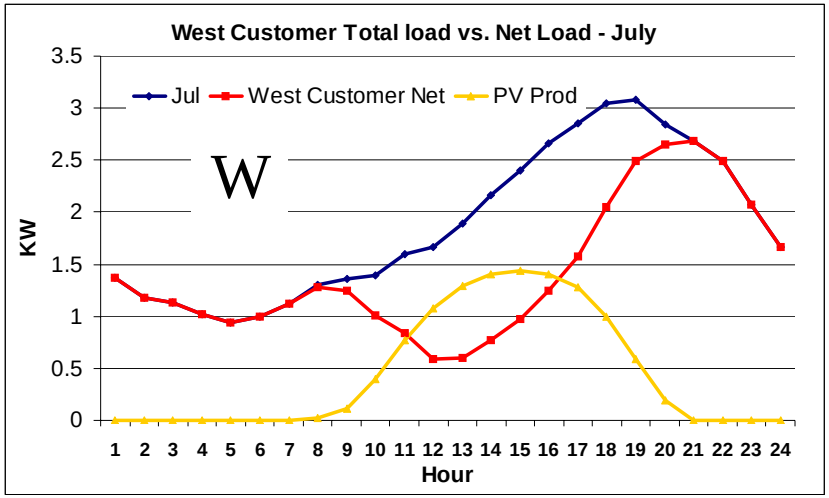
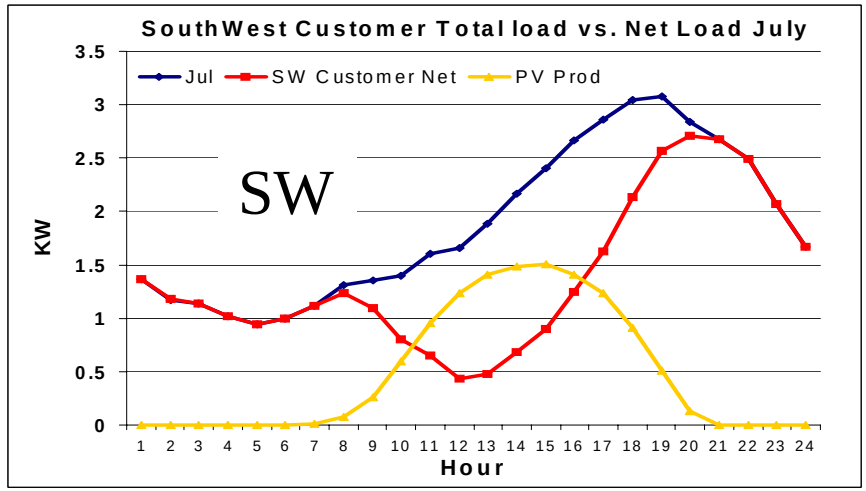
Why Peak Shaving?

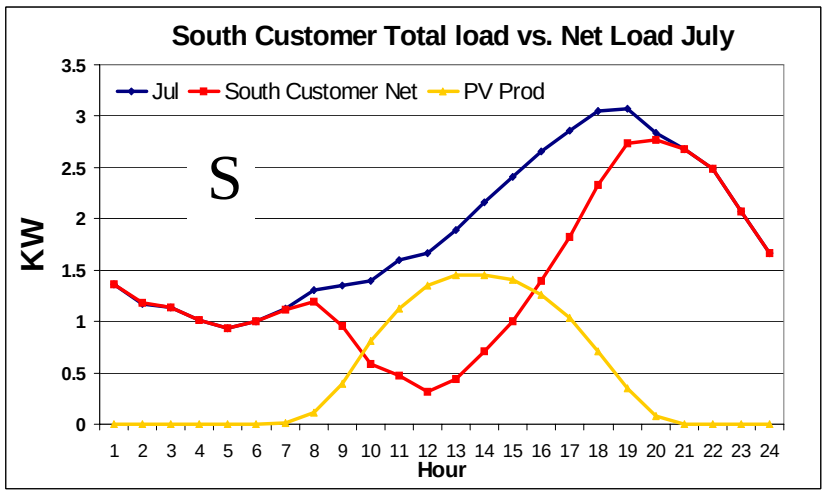
- Reduce Peak Liabilities
  - Economical
  - Reliability
    - o Limit Voltage Dips
    - o Reduce Need for New Capacity

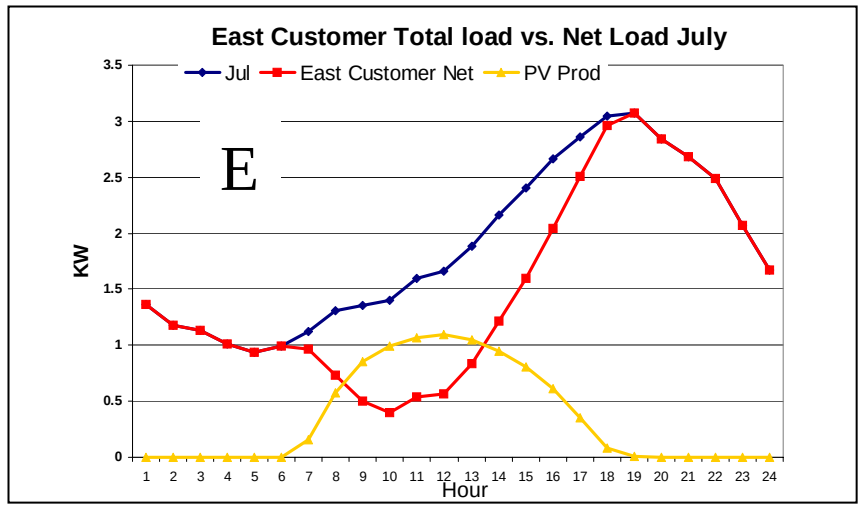


Hourly Curves - July



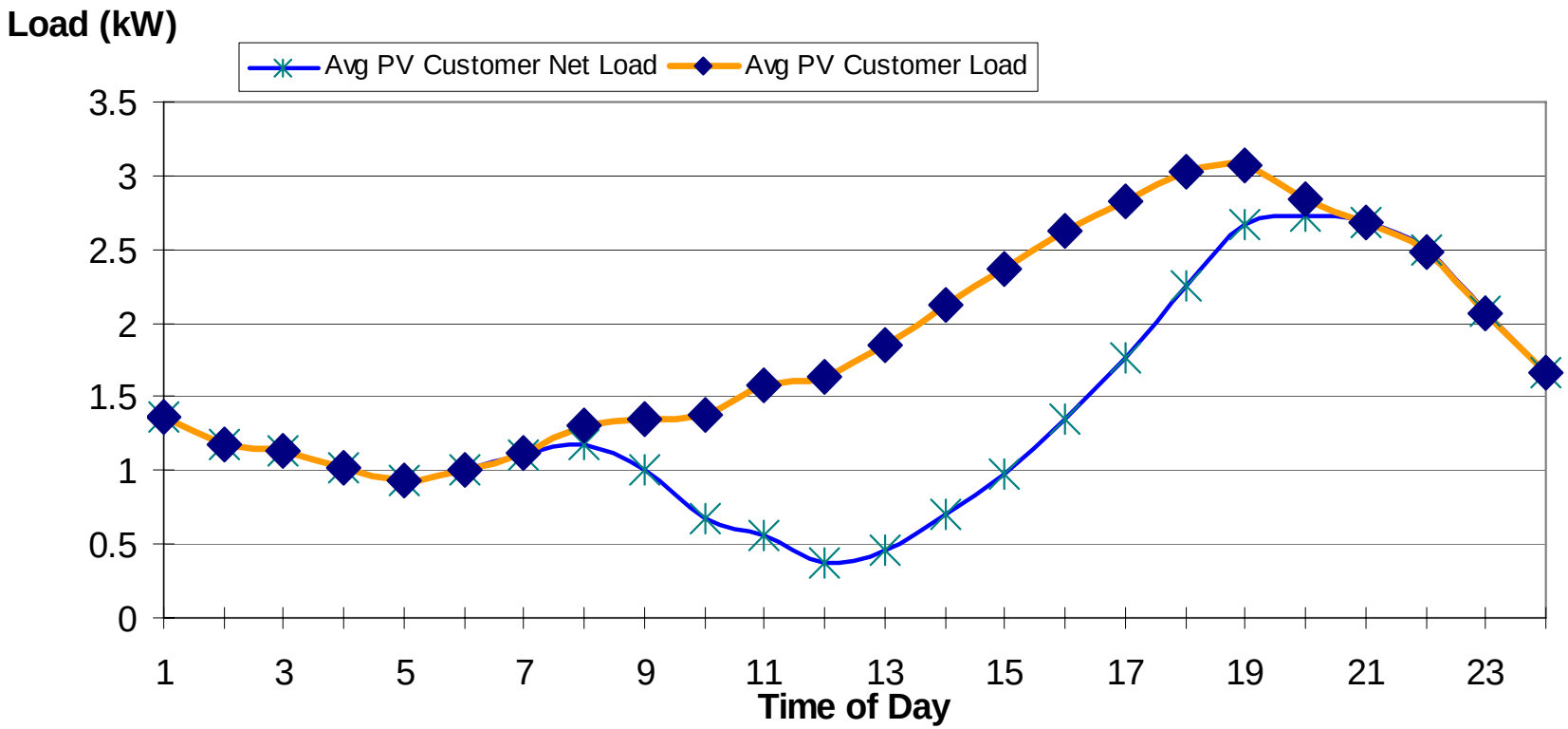




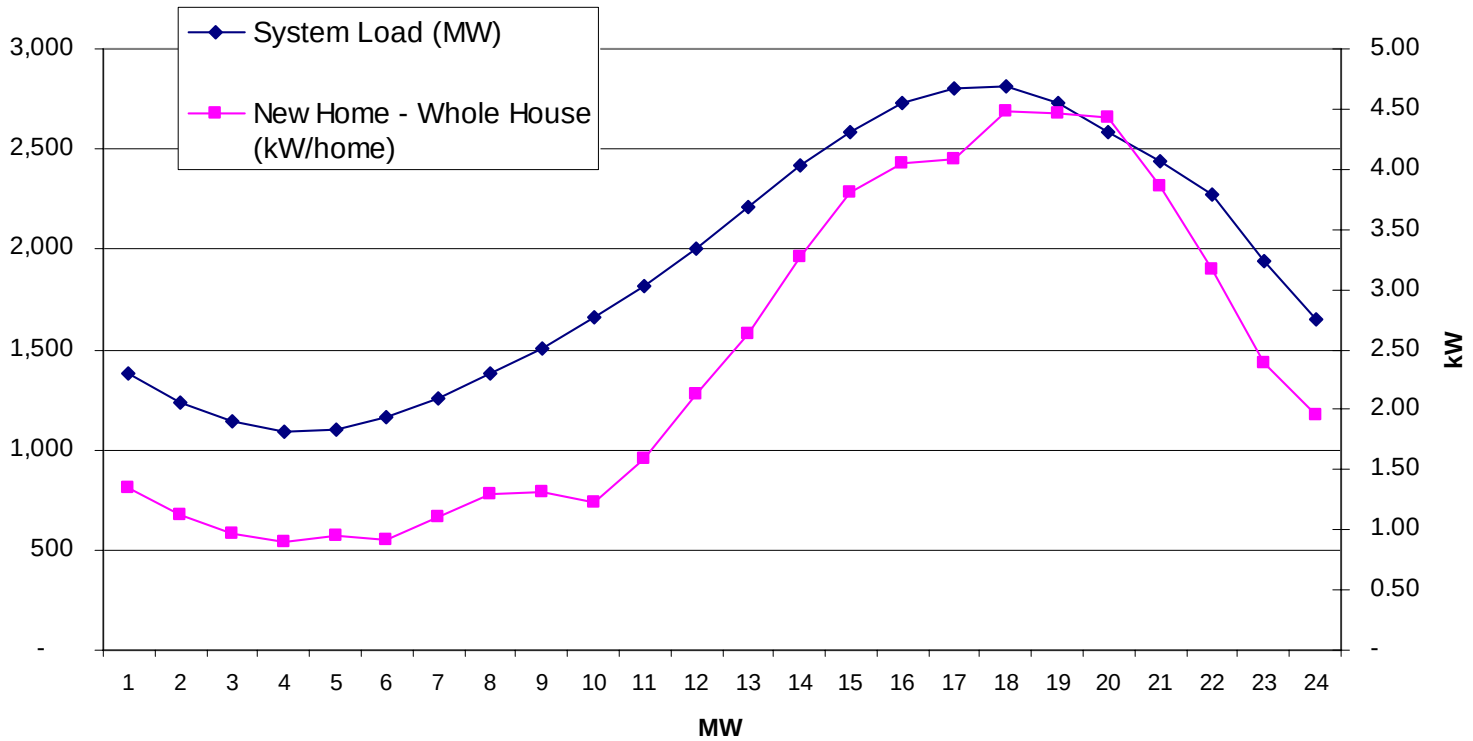


Average SMUD PV Customer Load vs.. Net Load

PV systems can reduce a customer's peak demand by as much as 13 percent (0.4 kW).

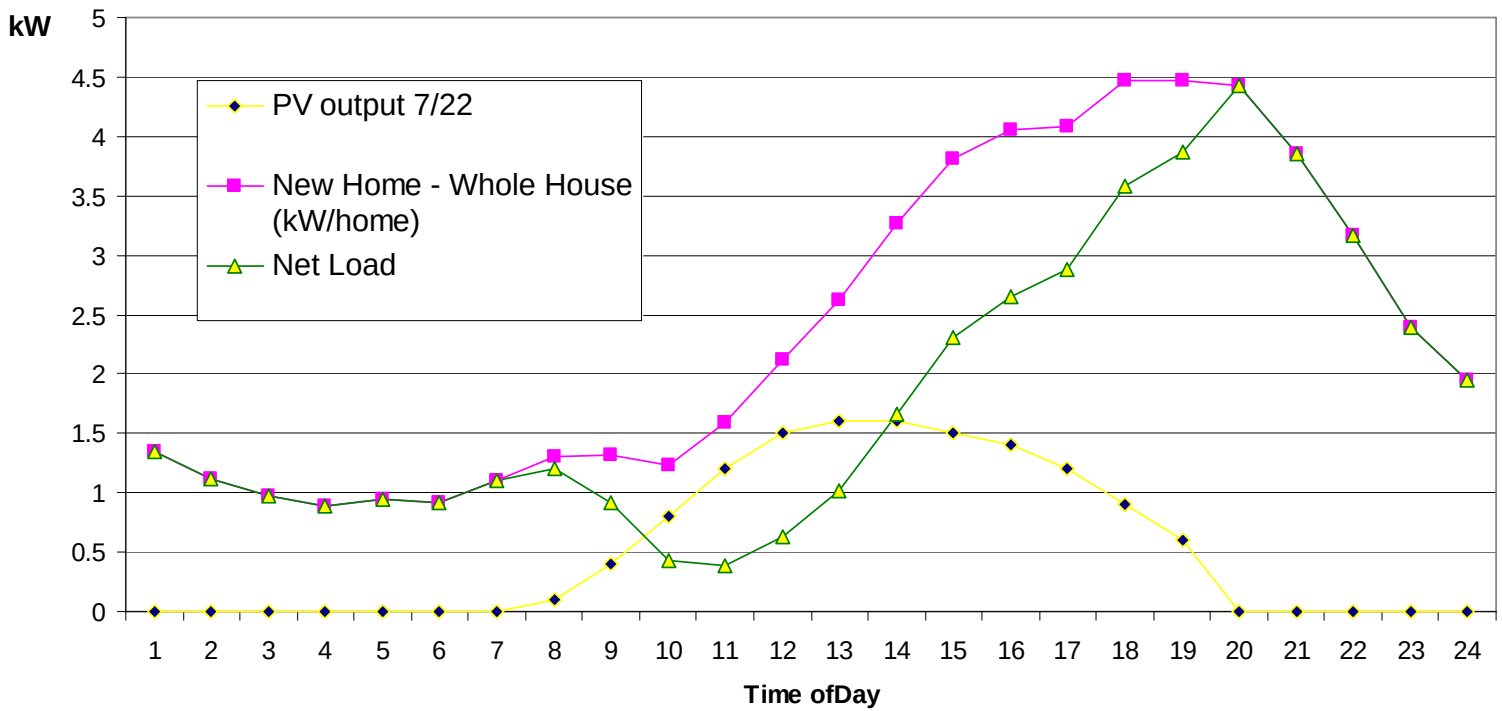


System Load July, 2003 vs.. New Home Load



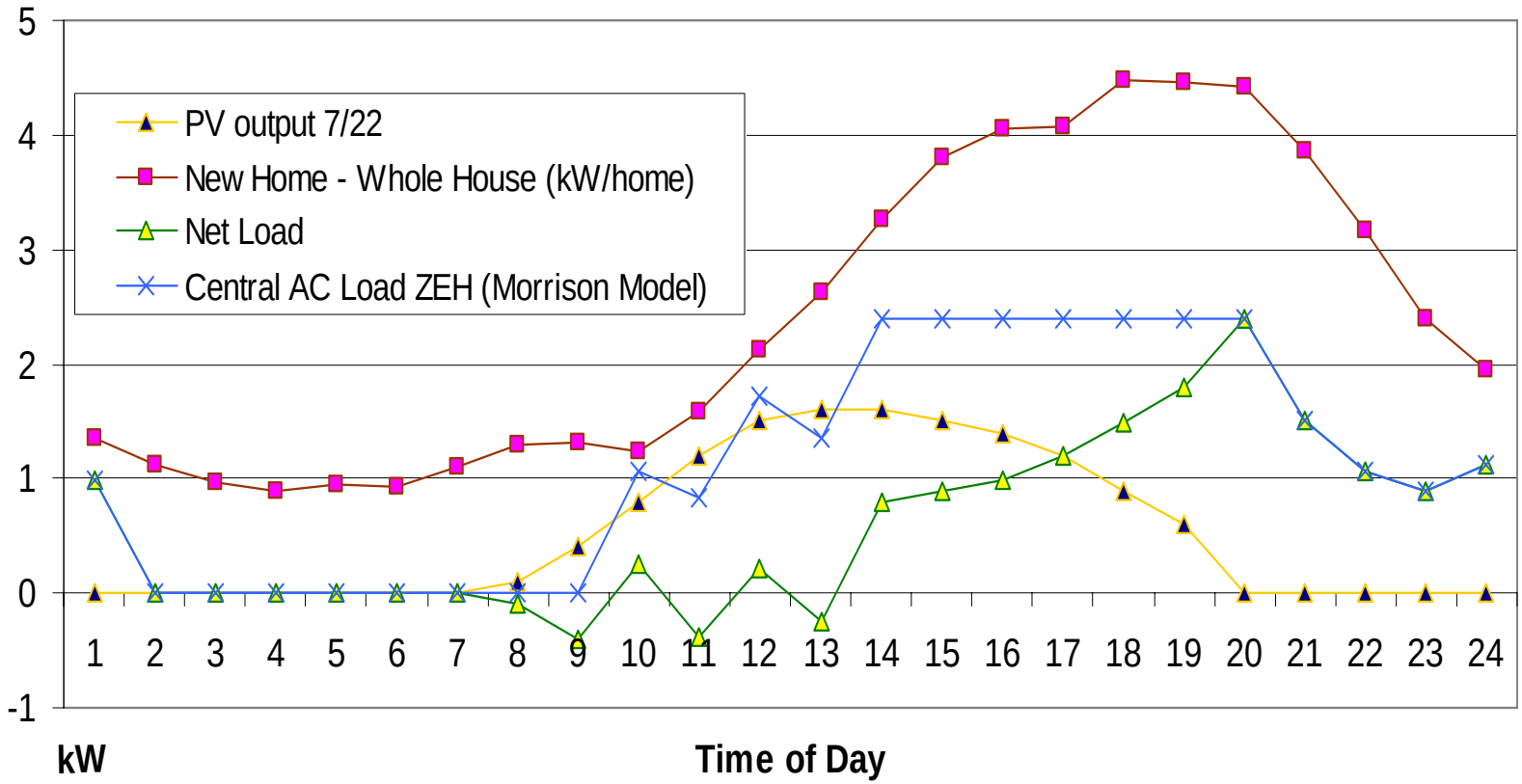
New Home Load with PV Production

Average New Home's peak demand measured at 6 pm is reduced 20 percent (0.9 kW)



ZEH Peak Demand Potential

Combination of PV and Efficiency yields potential peak demand reduction of up to 58% (2.6 kW) for Average New Home.



Peak Shaving Opportunities

- West or Southwest facing systems provide the best combination of peak reduction, super-peak energy, and annual energy production
- Targeting deployment to grid constrained areas will be more advantageous in the near to mid-term considering size in relation to State's grid
- Working with builders to orient roof integrated arrays to W or SW would provide maximum benefit
- Stable pricing provided by distributed PV can protect against grid price spikes like those seen in 2001, but only with large enough penetration.

Next Steps

- Side-by-Side Evaluation of ZEH vs. Non-ZEH Communities
  - Power production
    - Monitor energy savings/production
    - Monitor peak demand savings
  - Evaluate distribution system impacts
    - Voltage Flicker and Harmonic Distortion
- 100+ ZEHs in 05
- Demonstrate new Roof-integrated PV Product
- Adopt ZEH into SMUD's residential new construction program

Lessons Learned

- Production builders will build ZEHs with proper incentives and support and buyers like PV/ZEH
- PV system costs fall with volume
- ZEH production homes offer substantial electric utility bill savings and ZEH home owners use less electricity
- ZEH production homes offer potential for significant peak load reduction and distribution system benefits

Lessons Learned

BUT

- Builders need PV with proper products, incentives and support
- Builders want branded, turnkey systems backed by long-term warranties and service
- kWh/kW, distribution system savings need to be documented

For More Information:

Mike Keesee
(916) 732-5244
mkeesee@smud.org